ASSESSMENT OF CHEMICAL OXYGEN DEMAND REDUCTION IN ANAEROBIC PASTEURIZATION DIGESTER LATRINE (APDL)

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ABSTRACT

Human waste disposal in most of developing nations is a real problem. Mostly pit latrine is used for disposal of human waste and in places where the water table is very low it can lead to ground water contamination and thus environmental sound technology for Human waste disposal is necessary .Human waste disposal facility should reduce the Chemical Oxygen Demand(COD) significantly. This study therefore aimed at assessing Chemical Oxygen Demand reduction in Anaerobic Pasteurisation Digester a new technology for human waste disposal. The specific objectives were to determine the mean levels of COD in influent and effluent and to determine the percentage COD removal. The study was done in Sogomo estate in Eldoret Kenya and only one APDL plant was studied called Central APDL for four months. Two samples and there replicates were collected. I.e. influent and effluent from central APDL and taken to biotechnology laboratory in University of Eldoret. They were diluted and refluxed for two hours using acidified $K_2Cr_2O_7$ and the residue oxidised using Ferrous Ammonium sulphate(FAS) in a back titration using Ferroin indicator to reddish brown point of colour change and the volume of FAS recorded to aid in calculating COD value. The study results showed that the levels of COD were high in Influent and low in effluent. The percentage removal was 95.1425 ± 0.2281 % .Therefore there was significant reduction of COD in APDL. The research concluded that there was significant reduction of COD in APDL therefore i recommended the use of APDL for human waste disposal , polishing of effluent before discharge to environment and finally further research on efficiency of APDL in terms of reducing other parameters such as faecal coliform, nutrients, heavy metals and BOD.

ASSESSMENT OF CHEMICAL OXYGEN DEMAND REDUCTION IN ANAEROBIC PASTUERASATION DIGESTER LATRINE

BY

NDEGE RICHARD WANJOHI

A RESEARCH PROJECT SUBMITTED TO SCHOOL OF ENVIRONMENTAL STUDIES, DEPAERTMENT OF ENVIRONMENTAL BIOLOGY AND HEALTH IN UNIVERSITY OF ELDORET IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENVIRONMENTAL STUDIES SCIENCE

MAY 2014

DECLARATION

Declaration by Student

This research project is my original work to the best of my knowledge and has never been presented to any other institution of higher learning for the fulfillment of Bachelor Degree.

Signature……………………… Date…………………………

Ndege Richard Wanjohi

ESS/16/10

Declaration by Supervisor

This research project has been submitted for examination with my approval as a university supervisor. It meets the basic requirements' for the fulfillment of Bachelor Degree of university of Eldoret.

Signature………………………… Date: ……………………..

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DEDICATION

I would wish to dedicate this work to my parents Mr. and Mrs. Ndege all for their enormous support they gave to me during the time of this research study and during writing of this research project report. I wound also want to dedicate this work to my sisters Josphine Ndege and Millicent Ndege for your great support during the time I was doing this research project. You are all such a blessing to me, May God bless you all.

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ABSTRACT

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Thanks to my family especially dad and mum, Mr. and Mrs. Ndege for their financial support you gave to me to ensure that the research study is accomplished. You are all a blessing to me may God bless abundantly

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LIST OF ACRONYMS

COD ………………………………………...Chemical oxygen demand

APDL ……………………………………….Anaerobic pasteurization digester latrine

BOD……………………………………….Biological oxygen Demand

MAC…………………………………… …..Mixed adsorbent carbon

CAC …………………………………… …..Commercial activated carbon

APC……………………………………….Avocado Peel Carbon

TSS………………………………………..Total suspended solids

SS………………………………………….Suspended solid

MBRs……………………………………...Membrane Bio-reactors

EAT………………………………………. Equalization and Aeration Tank

WWT……………………………………….Waste Water Treatment

FAS ………………………………………..Ferrous Ammonium Sulphate

BOD ……………………………………….Biological Oxygen demand

NEMA……………………………………...National Environmental Management Authority

CHAPTER ONE: INTRODUCTION

1.1 Back ground information

A total of 3.4 million people, mostly children, die every year from water-related diseases from drinking, swimming in or washing clothes in polluted water. (Cofie, Agbottah et al. 2006). Lack of sanitation is a serious health risk and an affront to human dignity. It affects billions of people around the world, particularly the poor and disadvantaged. If the trend continues as currently projected, by 2015 there will be 2.7 billion people without access to basic sanitation. In the wake of disasters as much as in everyday life, public health interventions that secure adequate sanitation in communities prevent the spread of disease and save lives.(Dye, Reeder, & Terry, 2013)Hundred and twenty children die from the effects of bad sanitation daily globally. These children are dying from common diseases that are preventable. Human waste is a silent tragedy made worse by a scandalous lack of political will among governments to tackle the issue of poor sanitation. In the developing world 80% of disease is due to poor sanitation. Many of the sanitation facilities like the pit latrine that is not in good condition enhance chances of the spread of the diseases. Pit latrine is the most cheapest and basic form of “improved” sanitation available.

Human waste contains many quantities of oxygen-consuming substances in the complete chemical breakdown of organic substances in water. These highly oxygen consuming substances become a real problem in the environment especially if the sewer system drains into a water source. Left untreated or partially treated, discharged water contains effluent organics that compete with downstream organisms for oxygen. This oxygen demand can kill or inhibit life downstream of the discharge area. Therefore there is need to reduce some of these oxygen demanding substances as much as possible. Such organic substances are to be reduced to universally accepted standard or to standards of the authorizing agency. Such oxygen demanding compounds is the chemical oxygen demand.

Chemical oxygen demand (COD) is one of the most important parameters in water quality assessment and monitoring.(Li, Zhang et al. 2012). Therefore an Environmentally sound facility for human waste disposal better than commonly used pit latrine is critical. A new technology called Anaerobic Pastueralisation Digester Latrine (APDL) was under pilot on to which reduction of COD was assessed.

1.2 Statement of the problem

Sogomo estate is growing at a high rate especially with the increase of students from university of Eldoret. Human waste in Sogomo is mostly disposed using pit latrine. Pit latrines are increasingly being dug and with time space to dig these pit latrines will lack since most of plots are eighth, and quarter in size. Therefore, with time proper human waste disposal is to be an issue. The water table in Sogomo is very low thus the ground water will be contaminated.

Ineffective human fecal matter disposal can cause variety of ailments that can be spread by exposure to pathogens in feacal matter. Chemical oxygen demand is a real problem in the environment when in high accumulation (Series, 1997).High accumulation of chemical oxygen demand can leads to; active de-nitrification to occur under anoxic conditions that does not involve molecular oxygen, but rather chemical forms (e.g., nitrite, nitrate, sulfate, etc.) with combined oxygen atoms. (Zafarzadeh *et al* 2011) . High accumulation of COD also endangers the physical and chemical structure of the soil when applied to soil as fertilizers thus decreasing the crop yield. This has called for a need to try a new way of safely disposing the human waste other than the common pit latrine, thus the APDL project on which assessment of whether there is organic reduction (COD) was done.

1.3 Objectives

1.3.1 General Objective

To assess the COD reduction in the anaerobic pastueralisation digester latrine.

1.3.2 The Specific objectives

1. To determine the mean levels of COD in influent and effluent.

2. To determine percentage COD removal in APDL

1.4 Hypothesis

H $_{O1}$: The mean COD for influent and effluent are not the same.

H $_{02}$: The percentage COD removal will not be 100%

1.5 Justification of the research

The findings for the study on assessment of COD reduction in anaerobic pasteurization digester latrine were important because it gave concrete factual information on its efficiency as a latest technology of human waste disposal in terms of organic (COD) and render it recommendable as a suitable facility for human waste disposal. That was in turn to give justification why it's a better facility as compared to other facilities of human waste disposal that do not really yield much benefit such as fertilizer generation and methane production and high percentage removal of COD.

The findings were also to help to add knowledge on COD reduction in human waste disposal. It was also important to mention that the research was also to create basis for other researcher who would want to study on the same facility since it's a new technology. This is because it will provide the information to further studies and provide areas that will be limited in scope.

1.6 Scope of the study and limitation

The research was carried out in Sogomo Estate in Uasin Gishu County. The study took three months so as to ensure ample time for data collection, analysis and result presentation and submission. Time and funds were limited factors in this study and thus only one APDL plant was studied to arrive into conclusion of the findings.

CHAPTER TWO: LITERATURE REVIEW

There are several researches that have been conducted in the field of COD reduction and relates to this research work.

2.1 Membrane Bio-Reactor and Activated Sludge in COD reduction.

The domestic wastewater contains pathogens, suspended solids, nutrients (nitrogen and phosphorus), and other organic and inorganic pollutants (Andrew *et al*., 1997). To minimize the environmental and health hazards, these pollutants needs to be reduced to permissible limits for safe land disposal of wastewater (Manju *et al*., 1998; Poots *et al*., 1978). Therefore, removal of the organic contaminants and pathogens from wastewater is of paramount importance for its reuse in different activities (Ali and Deo, 1992; Chen, 1997).

Present conventional wastewater treatment technologies adopted in industrialized nations are expensive to build, operate and maintain (Mazumder and Roy, 2000; Piet *et al*., 1994; Mazumder and Kumar, 1999), especially for decentralized communities. Research work is in progress for the development of treatment technologies suited to these decentralized communities (Wang *et al*., 2005). Fly ash can be used as a promising adsorbent for removal of various types of pollutants from wastewater. Low-cost adsorbents of different origin like industrial waste material, bagasse fly ash and jute-processing waste can also be used for removal of organic matter from wastewater (Bhatnagar, 2007; Banerje and Dastidar, 2005). The COD concentrations play an important role in the re-use of these waste effluents.

Adsorption-based innovative technology (Devi and Dahiya, 2006) developed with low-cost carbonaceous materials showed good potential for COD removal from the domestic wastewater. (Devi and Dahiya 2008) studied COD and BOD reduction of domestic wastewater using discarded material based mixed adsorbents (mixed adsorbent carbon, MAC and commercial activated carbon, CAC) in batch mode.Under optimum conditions, maximum COD and BOD reduction obtained using MAC and CAC was 95.87, 97.45, 99.05 and 99.54%, respectively.

The results showed that MAC offered potential benefits for COD removal from wastewater. (Devi *et al*. 2008) made the assessment of reduction of Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) of wastewater from coffee processing plant using activated carbon made up of Avocado Peels. The maximum percentage reduction of COD concentration under optimum operating conditions using Avocado Peel Carbon (APC) was 98.20 and with Commercial Activated Carbon (CAC) this reduction was 99.02%.As the adsorption capacity of APC is comparable with that of CAC for reduction of COD and BOD concentration, it could be a lucrative technique for treatment of domestic wastewater generated in decentralized sectors. (Jefferson *et al*. 2000) evaluated the potential of membrane aeration bioreactors (MABR), Biological Aerated Filters (BAF) and membrane bioreactors (MBR) for grey water recycling. (Gander *et al*.2000) evaluated the relative efficiencies of three membrane materials for use in a submerged membrane bioreactor treating domestic wastewater.

They found that the Carbonaceous Biological Oxygen Demand ($CBOD_5$), COD, Suspended Solids (SS), NH3-N and turbidity removal was similar with the poly-sulphone (PS). (Melin *et al*. 2006) stated that membrane bioreactors (MBRs) are a promising process combination of activated sludge treatment and membrane filtration for biomass retention. The Chemical Oxygen Demand (COD) removals in excess of 95% were achieved in a 6 h nominal detention time. This study demonstrated that the membrane aeration can provide simultaneous BOD and Nitrogen removal in the same reactor. (Mohammed *et al*. 2008) investigated the efficiency of Membrane bioreactors (MBRs) for high reduction of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) and ammonia nitrogen (NH3-N). The results showed that removal efficiencies for the MBR varied from 97.8 to 99.9% for COD, 98.9 to 99.9% for BOD and 91.0 to 99.9% for NH3-N. (Lew *et al.* 2009) used the microfiltration anaerobic membrane bioreactor (An MBR) for the treatment of domestic wastewater.

They observed a constant COD removal of 88% in the reactor.(Al-Jlil. 2009) studied the COD and BOD reduction from domestic wastewater using sedimentation, aeration, activated sludge, sand filter and activated carbon in a sewage treatment process. He found that the mean maximum COD and BOD reduction was 92.17 and 97.66%, respectively. The sewage treatment system

using different materials (sand filters, activated sludge) showed excellent potential for COD and BOD removal from domestic wastewater.

According to (Al-Jlil 2009) Mean COD ranged between 81-10.5 mg L^{-1} in various treatments (the reduction in COD was significant among the various sewage water treatments ($LSD_{0.05}$ = 17.552). The reduction in COD was 48% (Equalization and Aeration Tank, EAT), 95% (MBR with aeration) and 98.5% in the final product water. The difference in COD reduction between the raw sewage and EAT was significant. This showed that simple aeration of sewage water can reduce the COD significantly by oxidation process. Although, there was a decreasing trend in the COD reduction from MBR stage to the final product water but the difference was not significant.

2.2 Fly ash, brick kiln ash and commercial activated carbon in COD reduction

The potential of fly ash, brick kiln ash and commercial activated carbon is determined for the reduction of chemical oxygen demand (COD) from domestic wastewater.(Devi and Dahiya 2006) Laboratory experiments are conducted for investigating the effect of treatment time, adsorbent dose, pH of the media, initial COD concentration, and agitation speed and particle size of adsorbents on the COD reduction from the domestic wastewater. Starting with an initial COD concentration of 1080 mg/l the maximum COD reduction achieved for fly ash was 87.84%, brick kiln ash was 83.22% and commercial activated carbon was 99.35 %. (Devi and Dahiya 2006)

These values were achieved when the wastewater was treated with activated carbon for 180 min, fly ash 250 min and brick kiln ash 300 min and the adsorbent dose was kept respectively at 40 g/l, 60 g/l and 45 g/l for activated carbon, fly ash and brick kiln ash. (Devi and Dahiya 2006) Agitation speed was kept constant at 600 rpm and the pH was maintained at 2 for activated carbon and fly ash and 5 for brick kiln ash. The maximum percent reduction is for 0.053 mm or smaller size of the particles. Though the adsorption capacity of the ash for reducing the COD is lower than that of the commercial activated carbon, the low material cost can make it an attractive option for the treatment of domestic wastewater.

2.3 Biodegradation of Sewage Wastewater Using Autochthonous Bacteria

(Vymazal, 2011) studied the effect of three-stage experimental constructed wetlands for the treatment of sewage and reported that 84.4% of the COD was removed. Microbial fuel cell with

ultra sound pretreatment was assessed by(Jiang, 2011), and it was observed that from raw sewage total COD removal rate was 11.3% to 19.2% and in case of pre-treated sludge it was 25% to 57%.

An integrated sludge digester system was observed in temperate climates (Lew B 2011), and it was seen that, with decrease in temperature, the COD removal decreased from 78% at 28°C to 42% at 10°C. On the other hand, (Sabry, 2008) studied the application an integrated sludge digester of inoculated with flocculent and granular sludge for treating sewage. After 4 h of retention time, 3-4% of the COD was removed. Studies on effects of bed materials on the performance of an anaerobic sequencing batch biofilm reactor that was used for treating the domestic sewage; results were analyzed, and it was revealed that the removal efficiencies for CODtot, CODsus, BOD_5, and TSS were 56%, 87%, 59%, and 81% for R1 and 58%, 90%, 60%, and 82% for R2, respectively.

2.4 Facilities used to reduce COD in human excreta

2.4.1 Pit Latrine

A pit latrine is used to retain resources inform of feaces underground for approximately two years making it less harmful and reducing its organics (COD) which requires space, with densely populated regions such as slum areas and in high sprouting centers, there are usually cost implications of repeated construction and emptying. They need relatively a longer period (two years) to reduce the organics or COD and making them less harmful. However, pit latrines do not show much reduction in COD as such and usually municipal waste water treatment plant is used.

2.4.2 Municipal waste water treatment plant

In primary treatment, wastewater that enters a treatment plant contains debris that might clog or damage the pumps and machinery. Such materials are removed by screens or vertical bars, and the debris is burned or buried after manual or mechanical removal.

The wastewater then passes through a comminutor (grinder), where leaves and other organic materials are reduced in size for efficient treatment and removal later. With grit removed, the wastewater passes into a sedimentation tank, in which organic materials settle out and are drawn

off for disposal. The process of sedimentation can remove about 20 to 40 percent of the BOD_5 and 40 to 60 percent of the suspended solids.

2.4.3 Anaerobic pasteurization digester latrine (APDL)

This is new technology facility for human waste disposal that is very different from other facilities that have been used to dispose human waste. In fact this is a technology that is under piloting. It is a further improved, or "advanced," sanitation system. Anaerobic Digestion-Pasteurization Latrine (ADPL) was developed by the Deshusses research group in the Civil & Environmental Engineering Department of Duke University.

The system operates by using an anaerobic digestion tank to receive human excreta from the latrine. Microorganisms living in the anaerobic (lacking oxygen) environment metabolize influent wastes and produce biogas. Biogas is a combustible gas comprised of approximately 65% methane, 35% carbon dioxide, and trace levels of other gases. Digested liquid leaving the digester enters a heating tank that is powered by burning the biogas produced. Plate 2.1 below shows the heating tank of the APDL system

Plate 2.1 Showing the heating tank of the APDL system

The effluent is heated to temperatures of 75°C to remove all pathogens. The process is made more efficient by adding a counter-flow heat-exchanger between the anaerobic digestion tank and the heating tank in the heat exchanger. The effluent leaving the system is sterilized, making it safe for environmental discharge. (Forbis-stokes & Colón 2012) Anaerobic digester for faecal waste is different from any convectional approaches in the way people think about and act upon human excreta because it takes an ecosystem approach to the problem of human excreta. A schematic of the APDL system is shown in figure 2.1

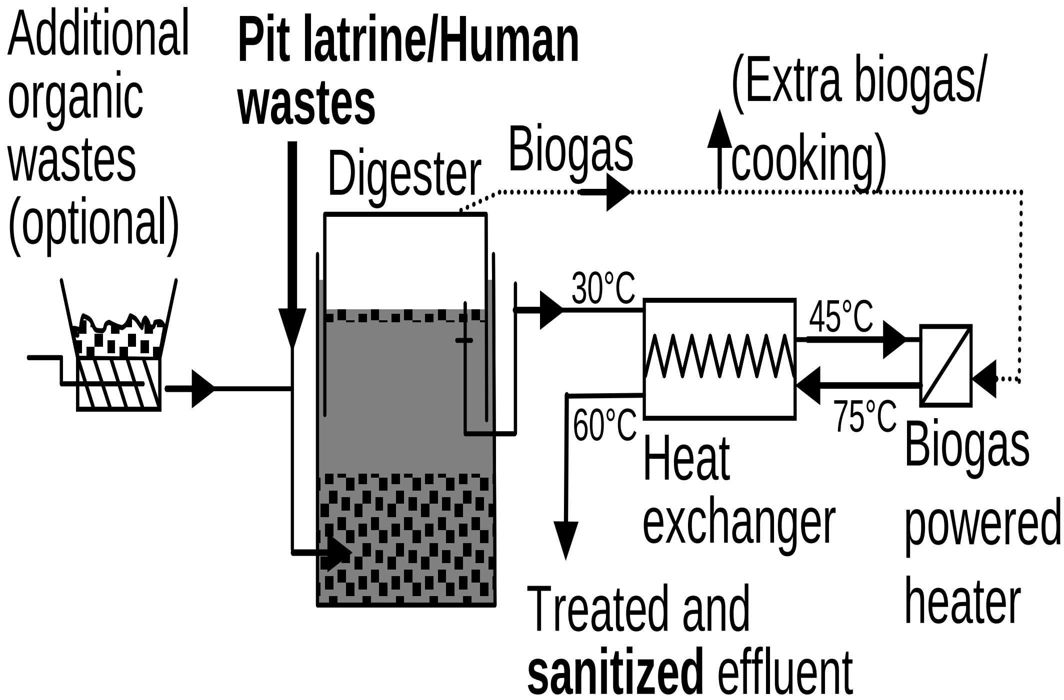

Figure 2.1 Showing a schematic of the APDL system

Three APDL plants were installed in Sogomo estate in Eldoret by the company and they were to be monitored for various parameters including fertilizer production and methane coliforms and COD reduction. Chemical oxygen demand reduction in the influent and effluent was measured weekly. Organic reduction was a primary indicator of sewage treatment. Currently, total, dissolved, and suspended chemical oxygen demand (COD) was the parameters used and are usually preferred for continued monitoring.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Area

The research was done at Sogomo market Centre that situated approximately 9 km from Eldoret town along Eldoret-Ziwa road in Uasin Gishu County. Sogomo lies on geo location of Latitude 0.52° North, Longitude 35.28° East (Figure 3.1) and at an Elevation of between 2110m and 2140m above sea level (Wafula 2009). The temperature typically varies from 10°C to 25°C and is rarely below 7°C or above 28°C. The warm season lasts from January 31 to March 28 with an average daily high temperature above25°C. The cold season lasts from June 18 to August 27 with an average daily high temperature below 22°C.

The annual precipitation average 1103mm.The rocks in this area are predominantly agglomerates and phonolites. Soils in Sogomo are predominantly nitisols, rich in organic matter and friable, and therefore susceptible to erosion Sogomo has a population of about 16000 people and recently habited by many students from the University of Eldoret. The water table in Sogomo is very near to the surface .Most of the plots uses bore hole as a source of water and there is no any municipal sewer system for human waste serving the area. Figure 3.1 shows a map of the study area.

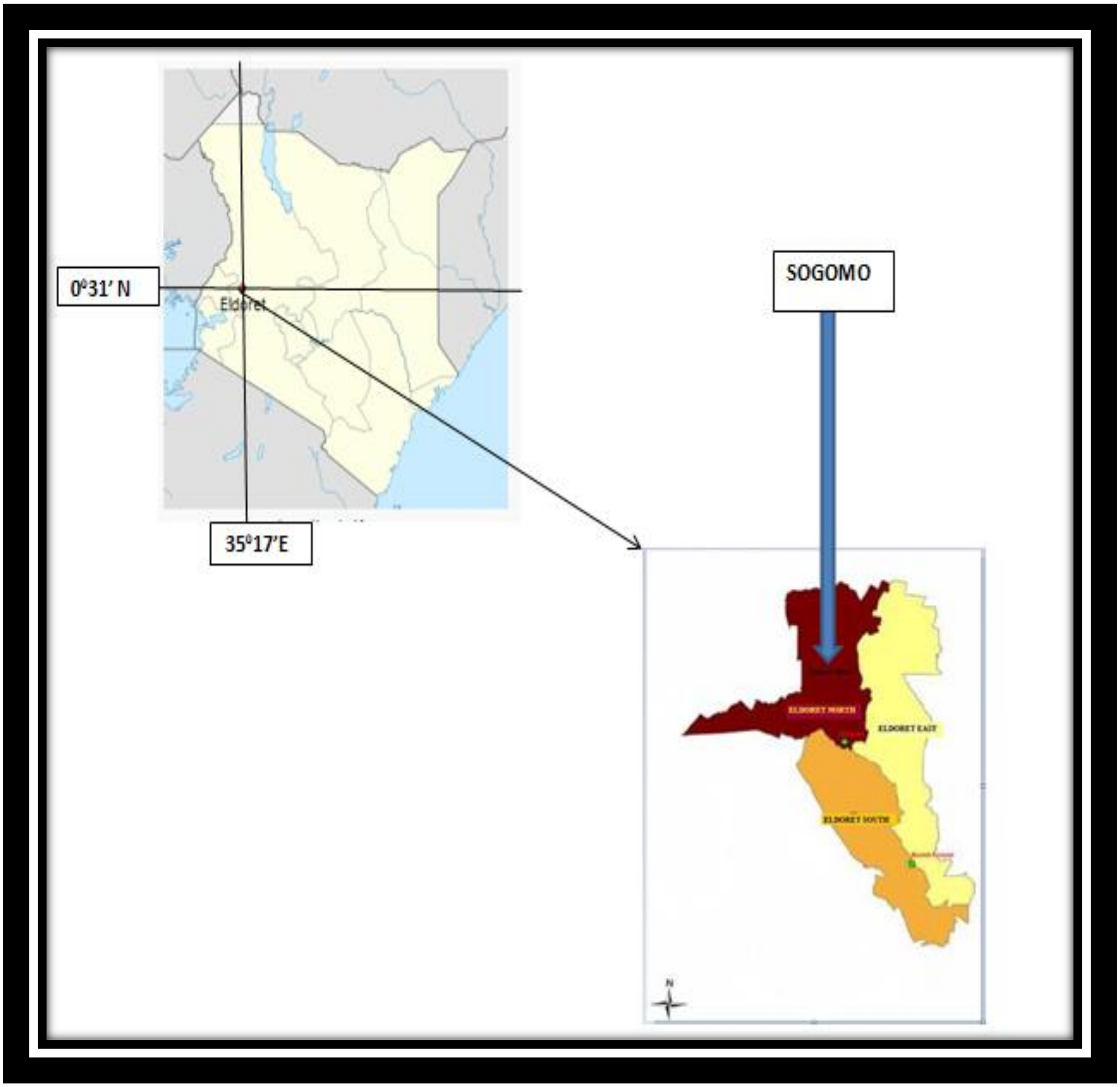

Figure 3.1 showing a map of the study area.

3.2 Research Design

The research employed true experimental design. Experimental research design was chosen because experiment can be replicated .Since experiment was done under a given protocol or procedure it was possible to replicate the same results under a similar set up and conditions. Secondly it allowed the control the variables. The experiment required a sample under test and a sample that was used as control so as to examine the variations. Therefore experimental design allowed the control of variables.

Finally experimental design resulted into quantitative data which was analyzed using inferential statistical test thus allowing drawing inference from the results hence accepting or rejecting the null hypothesis. Therefore the experimental design was justified for this research project.

3.3 Research population and Sampling frame

The population for the study was the APDL and target population was the APDL plants installed in Sogomo precisely the South, North and Central. The APDLs in Sogomo were chosen to be the target population because they were easily accessible therefore reduced the cost of the research. The fact that APDLs were already installed and functioning added weight to this justification. Therefore the sample frame consisted of the three APDL plants namely South, North and Central.

3.4 Sample and sampling Technique

Due to limited time and other resources, one APDL plant was chosen for study to arrive in to conclusion of this research. The APDL was sampled using probability sampling technique, precisely simple random sampling. Sampling was important in this research because it eliminated the problem of biasness. In addition it was a fair way of selecting the sample therefore eliminating sampling and experimental errors. Simple random sampling was done using table of random numbers.

3.5 Data collection procedure and tools

3.5.1 Reagents and Solutions

Potassium Dichromate, Concentrated Sulphuric acid, Ferrous Ammonium Sulphate (FAS), Silver Sulphate, Mercury sulphate, Ferroin Indicator solution and Organic free Distilled water.

3.5.2 Apparatus

50ml Burette and Burette Stand, 25ml Pipette and Pipette bulb, Four 500ml glass bottle, means of cooling, piped syringes, 50ml sampling bottle, water bath ,Four 250 ml beaker ,spatula, Electric weighing balance. 50ml measuring cylinder, 1000ml measuring cylinder,10 ml syringe.

3.6 Procedure

3.6.1 Sampling procedure

A pipe mounted on a syringe was used to take two samples in Central APDL. The first sample was influent that was collected from the pipe that takes human waste into the digester. The other sample was effluent that was collected at the sampling point before the effluent gets to the heat exchanger for heating. In both cases the samples were collected in replicates to enhance accuracy and reduce experimental error. For both samples sufficient amount of samples was collected and placed in well labeled sampling bottles that were fully decontaminated using organic free distilled water. The samples were sealed and placed in icebox and maintained at 4 ^{0}c and transported carefully to Biotechnology laboratory in University of Eldoret for analysis of the Chemical oxygen Demand (COD). Plate 3.1 below show sample collection from APDL.

Plate 3.1 Showing sample collection from APDL.

3.6.2 Laboratory procedure

3.6.2.1 Reagents preparation

0.1 Ferrous ammonium sulfate solution was prepared by weighing and dissolving 2.277 g of the solid FAS into a 200 ml liter of solution and adding distilled water to make up to 100ml mark. This solution was labeled 0.1 FAS solution. Potassium dichromate solution was prepared by weighing and dissolving 3.225g of solid potassium dichromate into 200ml of solution and adding distilled water to make up to 100ml mark. This solution was labeled 0.1 $K_2Cr_2O_7$ solution.

3.6.2.2 Determination of mean COD levels

20 ml of each sample collected from the field was measured using measuring cylinder and placed in 500ml glass bottle. These samples were diluted using 30 ml organic free distilled water to make 50 ml solution of each. Then control was prepared by measuring 50 ml of distilled water free from organics and placing in a 500ml glass bottle .Then in each of the glass bottles 1 g of silver nitrate was added. The content was shaken. Then 1 g of mercury sulfate was added to each of the glass bottle and the content shaken.

A 5ml of concentrated sulphuric acid was measured using 10 ml syringe and added to each of the glass bottles. 10 ml of $K_2Cr_2O_7$ solution was added and content shaken and corked.All the glass bottles were placed in the water bath at 92 ^{0}c temperature (Reflux) and refluxed for two hours at temperature of 92^{0}C. After two hours the residual mixtures for each bottle were let to cool to room temperature and diluted to twice their volume. Each of the diluted residual solution in glass bottles was titrated against Standard 0.1M FAS, using Ferroin indicator to a reddish brown end point and the titre value volume recoded. COD values were calculated using the formula below.

$$\text{COD mg/l} = \frac{(A - B)\,M * 8000}{V}$$

Where, A = volume of Fe $(NH_4)_4(SO_4)_2$ used for the control (ml)

B = volume of Fe $(NH_4)_4(SO_4)_2$ used for the sample (ml)

M = normality of ferrous ammonium sulphate

V = volume of sample (ml)

8000 = multiplier to express COD (mg/l)

The values of COD obtained from formula above were multiplied by 2 due to dilution factor. Plate 3.2 below shows experiment in progress during refluxing of samples in water bath.

Plate 3.2 Showing experiment in progress during refluxing of samples.

Plate 3.3 Showing Titration of Residual sample using FAS in laboratory

3.6.2.3 Determination of Percentage Removal of COD

After getting the mean values of COD for both influent and effluent the percentage COD removal was calculated using the formula below.

$$\textbf{\% COD Removal} = \frac{\textbf{Mean COD for Influent} - \textbf{Mean COD for effluent}}{\textbf{Mean COD for Influent}} \times \textbf{100}$$

The percentage COD removals for various weeks were recorded.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Results

4.1.1 Determination of the mean levels of COD in influent and effluent

The results showed that mean COD levels for Influents were high than mean COD levels .The levels of influent COD ranged between 1533.33 ml/L - 1302.54 mg/L .Week 1 had the highest COD levels of in influent while week 6 showed the least levels of COD in influent. The COD levels in effluents were ranging from 77.92mg/L -59.81 mg/L. Week 8 had the highest COD levels while week 6 had the lowest COD levels. The COD levels of influent were very high than the levels of effluent and thus were scaled down by ten so as to accommodate the scale for values of effluent. The results for levels of COD are show in Figure 4.1 below.

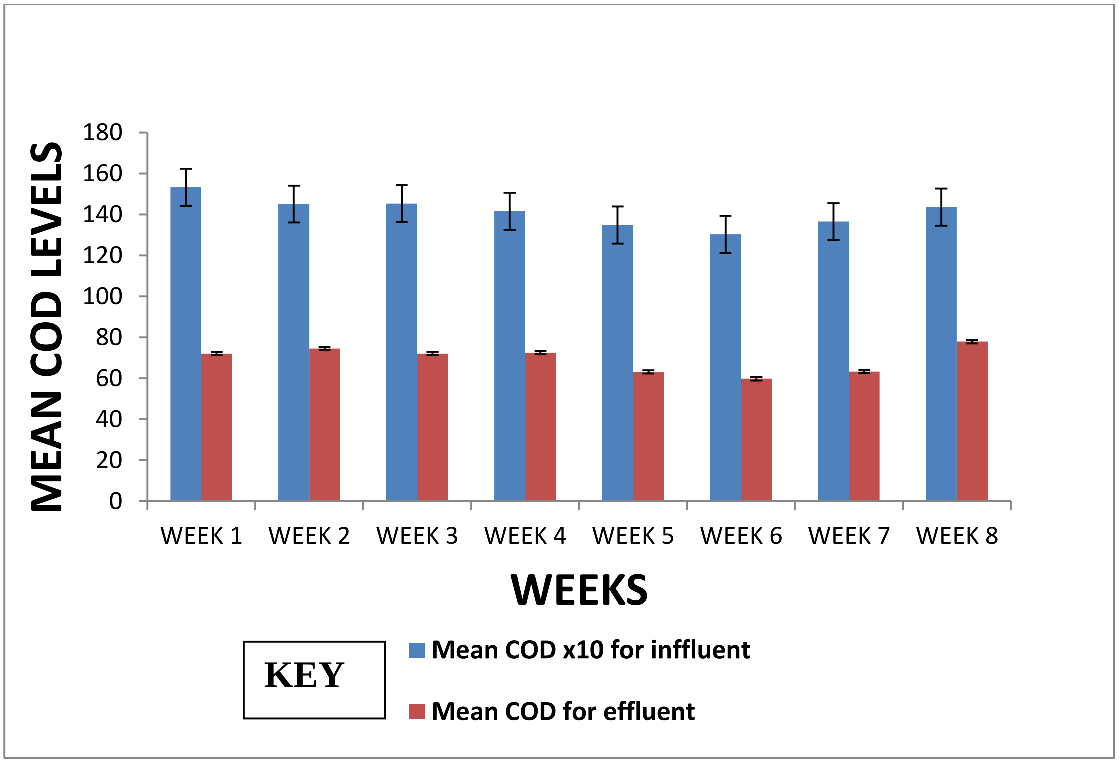

Figure 4.1 Showing Mean levels of COD for influent and effluent

4.1.2Determination of percentage Removal

The results showed that percentage removal was high at a percentage of 95.1425 ± 0.2281 %. The percentage removal was ranging between of 95.1425 ± 0.2281 %. – 94.57 %. The highest percentage removal was recorded in week 6 and the lowest percentage removal was recorded in week 8 as illustrated in figure 4.2 below.

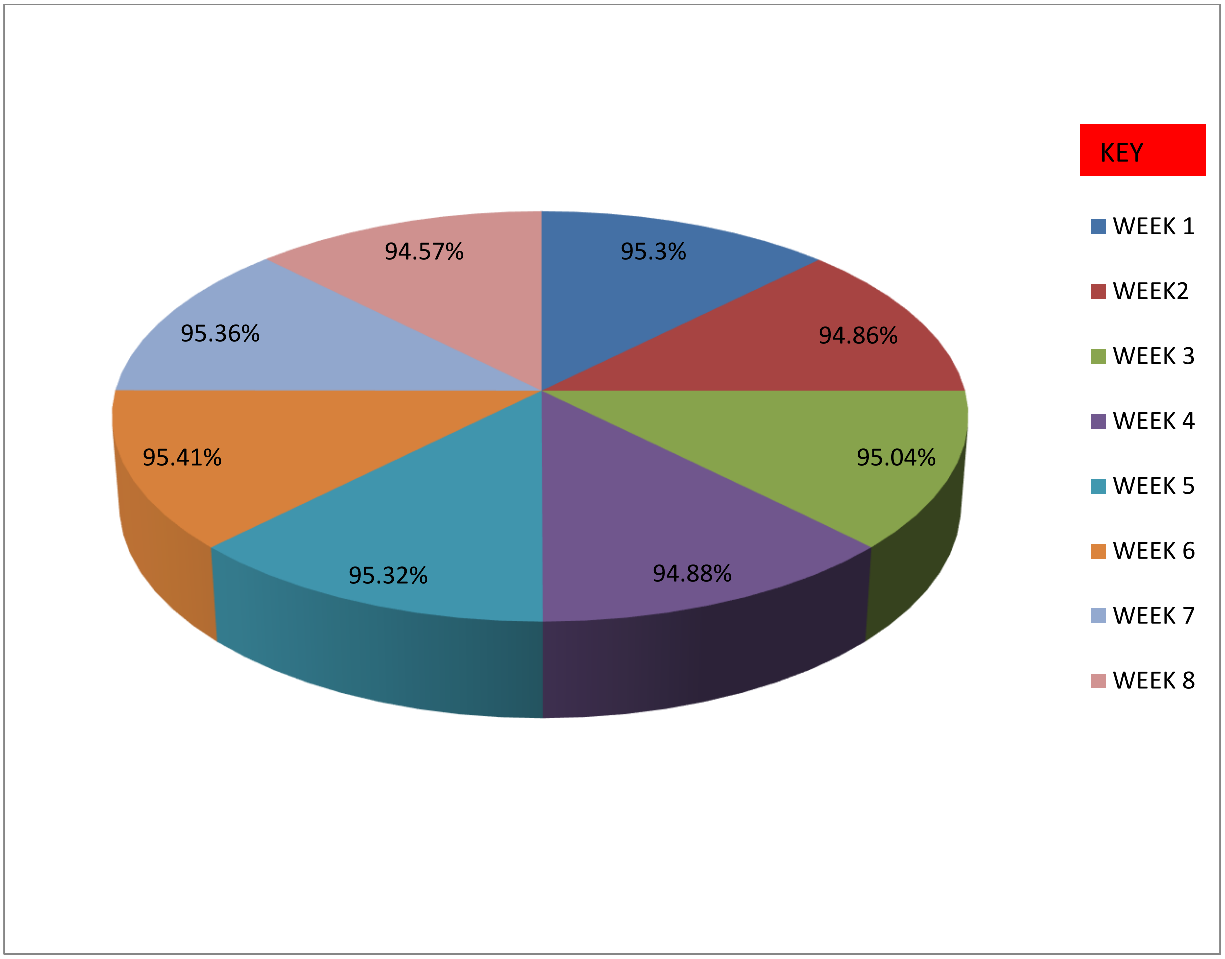

Figure 4.2 Showing the percentage COD removal in various weeks

4.2 Discussion

4.2.1 Determination of the mean levels of COD in influent and effluent

The results for Chemical oxygen demand (COD) levels showed that the levels of COD were higher in influents and low in effluent. This was because of reduction of COD by the facility. Micro-organisms in the digester broke down the organics in the human waste to derive food, energy , electrons and building materials for their cells.(Ardcavan and Wexford, 1997)

For influent the week 1 had the highest levels of COD while week 6 had the lowest COD level. This could have due to inefficient usage of the facility by the plot's residents. Therefore the micro-organisms could not reduce the COD. According to (Forbis,*et al* 2012) Micro-organisms are more efficient in reducing organics when usage of the facility is at best.

In both influent and effluent the value for standard deviation was large and this indicated that there were variation within the data levels of COD in influent and effluent. This could have been attributed to the usage of the facility such that different usage of the facility reflects different levels of COD especially in the effluent. The anaerobic microorganism in the digester increases or grows more when there is much substrate (human excreta). This means that the more the facility is used the more the ability of it to break organics (COD).

The first two weeks the usage of the facility was not good since most of the tenants did prefer to use the pit latrine instead of APDL to an extent where fresh cow dung was added to the digester to supplement anaerobic micro-organism's food .This could be justifying high levels of COD in the effluent in the first weeks.

The levels of COD for effluent were lower within week 5, 6 and 7 week respectively but they do not reach 50 mg/L; the standard requirement for COD by NEMA before releasing in to the environment and this supports or rather justifies the use of this effluent in another section before release into the environment, thus its application in agriculture as fertilizer to completely reduce COD. T-test analysis (Appendix 1.0) showed that the value of P value was greater than 0.05 (confidence level) and thus H_{01} was accepted.

4.2.2 Determination of percentage Removal

The APDL reflected a higher COD reduction since the overall mean percentage removal was 95.1425 ± 0.2281 %. APDL reduced the COD better than other methods that have been used to reduce COD. According to (Lew *et al.* 2009) use of microfiltration anaerobic membrane bioreactor for the treatment of domestic wastewater showed COD removal of 88% in the reactor. (Vymazal, 2011) studied the effect of three-stage experimental constructed wetlands for the treatment of sewage and reported that 84.4% of the COD was removed.

(Al-Jlil. 2009) studied the COD and BOD reduction from domestic wastewater using sedimentation, aeration, activated sludge, sand filter and activated carbon in a sewage treatment process. He found that the mean maximum COD and BOD reduction was 92.17 and 97.66%, respectively. The percentage COD removal was less than that of APDL. From the above cited previous research on COD reduction it is clear that APDL reduced COD significantly. Since COD are real problem in the environment there is need to reduce them to high percentages and if not reduced to zero mg/L it can be used in other section as fertilizer. (Manju *et al*., 1998; Poots *et al*., 1978).

Therefore, removal of the organic in waste (COD) is of paramount importance for its reuse in different activities (Ali and Deo, 1992; Chen, 1997). Since a reduction in the COD indicates human waste treatment by the system it is clear that the APDL significantly reduced the COD and thus an evidence of human excreta treated. In fact the presence of a small standard deviation value indicated better performance and consistency in most of the weeks. Though APDL reduces COD efficiently and with high percentage it does not reduce COD to NEMA standard requirement and this justifies why the effluent needs further polishing. Week 7 registered the highest percentage COD removal. In the week 5, 6 and 7 the percentage COD removal was high and this indicated better performance of the system. This could have been attributed to some of initiatives that were put in place. These initiatives included the encouraging the residents on the plot to which the APDL was installed to use the facility thus improved performance due to usage (Forbis,*et al* 2012), developing way of provision of flashing water, improvement of the piping of the system, provision of bin to dump the sanitary towels and finally the use of the posters on as a way of educating any user to the APDL facility.

The percentage removals were very close to each other in most of the weeks and this shows there was no significance difference between them. The chi-square analysis showed that the value of P (Appendix 2.0) was greater than 0.05 (Confidence level) and therefore there was no significance difference between the observed and the expected percentage COD removal hence H_{02} was accepted.

CHAPTER 5: CONCLUSION AND RECOMEDATION

5.1 Conclusion

This study aimed at assessing COD reduction in APDL in Sogomo and basing on the results the research arrived to the following conclusion, APDL facility reflected high levels of COD in the influent and low levels in the effluent .The overall percentage COD removal was 95.1425 ± 0.2281 % which was efficient. Therefore APDL was efficient in reducing the COD but effluent levels of COD were not within the NEMA Standard and thus further polishing of the effluent was required before discharge to the environment.

5.2 Recommendations

Basing on the results, I recommended the following;

1. Use of APDL for human waste disposal especially in developing world.
2. Further polishing of the effluent before discharge to the environment.
3. Further research studies on the efficiency of APDL in terms of reduction of other factors such as feacal coliforms, nutrients and BOD.

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APPENDICES

Appendix 1.0 Statistical T- test Analysis and Testing of Hypothesis

t-Test: Two-Sample Assuming Equal mean but Unequal Variances		
	Influent	Effluent
Mean	1413.035	69.4275
Variance	5240.006714	41.77036429
Observations	8	8
Hypothesized Mean Difference	0	
Df	7	
t Stat	52.291052	
P(T<=t) one-tail	1.22546E-10	
t Critical one-tail	1.894578605	
P(T<=t) two-tail	2.45092E-10	
t Critical two-tail	2.364624252	

Appendix 2 Chi Square Test Analysis and Testing of Hypothesis

OBSERVESED % COD	93.3	94.86	95.04	94.88	95.32	95.41	95.36	94.47
EXPECTED % COD	100	100	100	100	100	100	100	100
O-E	-6.7	-5.14	-4.96	-5.12	-4.68	-4.59	-4.64	-5.53
(O-E)^2	44.89	26.4196	24.602	26.214	21.902	21.0681	21.53	30.5809
(O-E)^2/E	0.4489	0.2642	0.246	0.2621	0.219	0.21068	0.215	0.30581
α	0.05							
Df	7							
chi square	2.17207							
Critical Value	14.07							
Reject Null hypothesis	NO							
chi square (P)	0.94971							
Reject Null hypothesis	NO							